no. 88-3

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REPLY TO: 3420

DATE: FEB 23 1988

SUBJECT: Biological Evaluation, Mammoth RD

TO: Forest Supervisor, Inyo National Forest

Enclosed is an insect and disease biological evaluation of three areas on the Mammoth RD conducted by the Forest Pest Management Group, State and Private Forestry staff. The areas evaluated were 1) the red fir belt east of San Joaquin Ridge, 2) a large annosus root disease area near Shady Rest campground and 3) a lodgepole-Jeffrey pine stand near the White Wing Work Center. For each area, the major insect and disease problems are identified, a prognosis given for what can be expected if no management action is taken, and the pros and cons of implementing various pest management alternatives discussed.

Any questions or requests for additional information should be directed to John Wenz or Gregg DeNitto of the Forest Pest Management Group.

BRUCE H. ROETTGERING
JOHN NEISESS
Program Leader
Forest Pest Management

Enclosure

cc: District Ranger, Mammoth RD w/ encl.
R. Porter, Mammoth RD w/ encl.

JWenz:cvm GAD 2/23/88
BHR 2/23/88

FOREST PEST MANAGEMENT
Pacific Southwest Region

Report No. 88-3

3420 Biological Evaluation
February 23, 1988

Biological Evaluation of Pest Conditions in the Red Fir Belt,
Shady Rest Root Disease Center, and White Wing Area,
Mammoth Ranger District, Inyo National Forest

Gregg DeNitto, Forest Pathologist
John Wenz, Entomologist

ABSTRACT

Three areas on the Mammoth Ranger District were evaluated for insect and disease conditions: the red fir belt area east of San Joaquin Ridge, an annosus root disease area near Shady Rest Campground, and a lodgepole-Jeffrey pine stand near White Wing Work Center. The most significant factors affecting the condition of the vegetation in the red fir belt is the overstocking throughout most of the area and advanced stand age; no major insect or disease problems were encountered. Such conditions, however, tend to predispose trees to pests, and without management of the vegetation, periodic fluctuations in mortality can be expected in the future, particularly during periods of drought. The annosus root disease area near Shady Rest Campground will continue to expand and centers will coalesce. Presently available techniques to limit further spread include measures that remove the host material for a prolonged period of time. Current mortality in the pine stand near White Wing appears lower than previously reported levels. Factors involved include the mountain pine beetle, overstocking and tree age. Activities directed at reducing stocking density and average tree size and age, should help reduce future mortality.

INTRODUCTION

In August, 1987, Ray Porter, Mammoth Ranger District, requested an evaluation of the "red fir belt" area. Future management direction for the area was being developed and the evaluation was designed to provide pest management input for consideration during the decision making process. The evaluation was conducted

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on September 22-25, 1987 by Gregg DeNitto, Forest Pathologist and John Wenz, Entomologist, Forest Pest Management Group, State and Private Forestry Staff. They were accompanied during the field examination by Ray and Jim Hoyt of the Mammoth District. Also at the request of the District, two additional areas were evaluated during the week: a large root disease center northeast of the Shady Rest Campground and a lodgepole-Jeffrey pine stand in the vicinity of the White Wing Work Center.

Each area is covered separately below and includes a discussion of possible management alternatives and the likely prognosis for the stands following implementation. These alternatives are directed toward actions that should influence pest conditions and subsequent effects on the vegetation. Implementation of any one or combinations of the alternatives will depend on compatibility with management direction and objectives for the area.

RED FIR BELT

Observations

The "red fir belt" is an area just east of San Joaquin Ridge (T. 3 S., R. 27 E., sections 18 and 19) within the Earthquake Compartment. It covers approximately 1,200 acres at the base of San Joaquin Ridge and is located on both the Mammoth and Mono Lake Districts. The area is unroaded and has been unmanaged in the past. Except for a cinder cone, the area is located on gentle terrain with most of the slopes less than 20%. The general aspect is northeast, with some east and west-facing slopes.

The primary tree species are red fir and lodgepole pine. Jeffrey pine, western white pine, and mountain hemlock are present at low levels in discrete locations within the area. The stands appear to be uneven-aged with a relatively closed canopy. Most of the area would be classified R4G with some pockets of L4N. At least three plant aggregations were recognized. The main aggregation is three-layered. The upper layer is made up of old red fir (estimated 500+ years) with 20-40% crown cover. The middle layer is red fir and lodgepole pine at varying proportions. Estimated age is 150-300 years; crown cover is 30-60%. The bottom layer is comprised of red fir from 10-100 years old; crown cover 10-30%. The second aggregation is two-layered and almost entirely red fir. The top layer is comprised of small and medium sawtimber red fir with an estimated age of 150-300 years. Crown cover of this layer ranges from 20-40%. The bottom layer is advanced red fir regeneration under 100 years; crown cover tends to be high, with a range of 30-70%. The third aggregation is also two-layered and contains more lodgepole pine than the other two. The upper layer contains mostly lodgepole pine with some red fir. Estimated age is 100+ years and crown cover 20-50%. Beneath the upper layer is red fir regeneration with a cover of 20-70%. Brush and forb species were not a significant component in any of the areas examined. Some grasses were observed in open areas, but were still a minor component.

In part of the defined "red fir belt", lodgepole pine stands exist. These stands appear marginal from the standpoint of growth and regeneration capability. They were not considered in this evaluation because of the major differences from the majority of the area.

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Each area is covered separately below and includes a discussion of possible management alternatives and the likely prognosis for the stands following implementation. These alternatives are directed toward actions that should influence pest conditions and subsequent effects on the vegetation. Implementation of any one or combination of the alternatives will depend on compatibility with management direction and objectives for the area.

RED FIR BELT

Observations

The "red fir belt" is an area just west of San Joaquin Ridge (T. 3 S., R. 27 E., sections 33 and 40) within the Sotcher Lake Compartment. It covers approximately 1,200 acres at the base of San Joaquin Ridge and is located on both the Mammoth and Mono Lake Districts. The area is unroaded and has been unmanaged in the past. Except for a cinder cone, the area is located on gentle terrain with most of the slopes less than 20%. The general aspect is northwest, with some east and west-facing slopes.

The primary tree species are red fir and lodgepole pine. Jeffrey pine, western white pine, and mountain hemlock are present at low levels in [illegible] locations within the area. The stands appear to be uneven-aged with a relatively closed canopy. Most of the area would be classified RF4 with some pockets of RF5. At least three plant aggregations were recognized. The main aggregation is three-layered. The upper layer is made up of red fir (estimated 300+ years) with 20-40% crown cover. The middle layer is red fir and lodgepole pine at varying proportions. Estimated age is 150-200 years; crown cover is 30-60%. The bottom layer is comprised of red fir from 10-70 years old; crown cover 10-30%. The second aggregation is two-layered and almost entirely red fir. The top layer is comprised of small sawtimber red fir with an estimated age of 150-250 years. Crown cover of this layer ranges from 20-40%. The bottom layer is advanced red fir regeneration under 100 years; crown cover tends to be high, with a range of 30-70%. The third aggregation is also two-layered and contains more lodgepole pine than the other two. The upper layer contains mostly lodgepole pine with some red fir. Estimated age is 100+ years and crown cover 20-50%. Beneath the upper layer is red fir regeneration with a cover of 20-70%. Brush and forb species were not a significant component in any of the areas examined. Some grasses were observed in open areas, but were still a minor component.

In part of the defined "red fir belt", lodgepole pine stands exist. These stands appear marginal from the standpoint of growth and regeneration capability. They were not considered in this evaluation, because of the major difference from the majority of the area.

Considering their age and stocking density, the red fir stands are in relatively good condition with respect to insects and diseases. Stalactiform rust (Peridermium stalactiforme) and western gall rust (Endocronartium harknessii) are present in lodgepole pine. Stalactiform rust is causing some top-killing and minor amounts of tree mortality. The main effects of western gall rust are branch galls and hip cankers. Neither of these rusts are having a major impact on the stands. Considerable branch mortality was seen on the larger red fir. In most cases, this mortality was reducing the live crown by 10-30%, although most of it was in the lower and mid-crown. At least two agents could be causing this flagging. A fungus, Cytospora abietis, is a common invader of red fir branches that are stressed. Twig beetles (Scolytus subscaber; S. praeceps) are also frequently found attacking branches of suppressed fir. These organisms are generally not considered serious pests of red fir, but their presence and activity suggest that affected trees are of poor vigor or under some type of stress. Affected trees in the red fir belt are probably stressed because of tree age, overstocking, and inadequate available soil moisture.

Little fir engraver (S. ventralis) activity was observed. Some pitch streaming on the upper boles of a few fir was seen, indicating fir engraver attacks, but top-killing and tree mortality were low and not significant factors in the stand. Similarly, very little mountain pine beetle (Dendroctonus ponderosae) activity was noted in lodgepole pine. Other organisms typical of old-growth red fir forests, such as Heterobasidion annosum and dwarf mistletoe, were not seen in these stands. Very little decay was observed, but some decay and cull will be encountered should harvesting occur.

Management Alternatives

1) No Action

No vegetation management would be scheduled or implemented. The present character and condition of the stands would likely continue unchanged for many decades. Some large, old-growth red fir would die most years. Top dieback would be predictive of some of this mortality several years prior to tree death. Most of this mortality, often involving the fir engraver, would be scattered individuals, with occasional occurrences of small, 2-3 tree groups. Smaller red firs and lodgepole pines would also likely die, primarily as a result of suppression and competition. Although mortality would vary periodically, average annual mortality should be less than 1 tree/acre. As trees in the upper canopy layers die, the larger, more thrifty trees in the understory would respond and grow into the upper canopy. Because of the high stocking levels, this would be a slow process and some suppressed individuals would be expected to die. Snow bending and breakage should continue to contribute to the suppressed condition of many trees.

There is some potential for an increase in fir engraver-related top-killing and mortality through time based on the number of susceptible hosts in the stands. To the extent that this occurs, the more vigorous understory trees and regeneration would grow into the upper canopy and occupy the openings. However, experience indicates that increased fir engraver activity is more likely in white fir than red fir stands. Periods of below normal precipitation

Considering their age and overall density, the red fir stands are in relatively good condition with respect to insects and diseases. Dwarf mistletoe (Arceuthobium abietinum) is present but not abundant. Cytospora canker, a fungus, Cytospora abietis, is a common invader of red fir branches that are stressed. Western gall rust (Peridermium stalactiforme) and western gall rust (Endocronartium harknessii) are present in lodgepole pine. Stalactiform rust is causing some top-killing and minor amounts of tree mortality. The main effects of western gall rust are branch galls and hip cankers. Neither of these rusts are having a major impact on the stands. Considerable branch mortality was seen on the larger red fir. In most cases, this mortality was reducing the live crown by 10-30%, although most of it was in the lower and mid-crown. At least two agents could be causing this flagging. A fungus, Cytospora abietis, is a common invader of red fir branches that are stressed. Twig beetles (Pityophthorus spp. and Pityokteines spp.) are also frequently found attacking branches of suppressed fir. These organisms are generally not considered serious pests of red fir, but their presence and activity suggest that affected trees are of poor vigor or under some type of stress. Affected trees in the red fir belt are probably stressed because of tree age, overstocking, and inadequate available soil moisture.

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would increase the likelihood of increased mortality. Similarly, in the aggregations with larger amounts of lodgepole pine, there is some probability of increased mountain pine beetle-related mortality. As the lodgepole pines increase in size and stocking levels increase, the stands will become more susceptible to increased beetle attack. If many of the overstory lodgepole pines were to be killed in these aggregations, the understory red fir would respond to release and eventually replace the pine. Because of the density of red fir regeneration, however, the response to such release would be slow.

2) Sanitation-Salvage

Periodic entries would be planned to harvest trees that are dead or expected to die prior to the next entry. Additional trees that are not producing any net wood volume because of decay and defect should also be removed. The first entry would likely have the largest sale volume over the next 5 or more decades. A sanitation harvest in this stand would remove trees from all merchantable size classes. However, most of the harvesting would occur in the largest size class of red fir and lodgepole pine. Some harvesting of smaller size classes would take place, especially of lodgepole pine. Harvesting of the large overstory trees would create small openings and would increase available soil moisture and light to the understory. Depending on the size of the openings and amount of damage to the understory during harvesting, a significant height growth response by the red fir understory can be expected within 5 to 10 years after logging. Removing some of the less vigorous green trees through sanitation from these stands would reduce stocking levels and alleviate some intertree competition. Although stocking might not be reduced to desired levels, some reduction may lessen stress and tree susceptibility to bark and engraver beetles, thus reducing future mortality potential.

Establishing marking criteria for the identification of red firs that may likely die prior to the next entry would be difficult. True firs appear to survive even when they are apparently in poor condition. A preliminary system to risk-rate true firs has been developed by George Ferrell of the Pacific Southwest Experiment Station. This system has not been validated for the southern Sierra Nevada, but it is the only source of information on which to base decisions at this time. Characteristics he has correlated with increased risk of mortality include crown class, live crown percent, recent top-kill and amount of crown missing within the live crown. Marking guidelines using these criteria may be developed by the District to increase the accuracy of identifying trees for sanitation harvest. (See General Technical Report PSW-39, Risk-rating systems for mature red fir and white fir in Northern California).

Although annosus root disease was not seen in these stands, creation of stumps and bole wounds could provide avenues for entry by the fungus. Because of the apparent common occurrence of <u>H. annosum</u>, it is likely to expect it to enter the stands at any opportunity. Because of the recreation and visual objectives for this compartment, it is advisable to treat any freshly cut conifer stumps with borax to minimize infections by the fungus. For similar reasons, harvesting restrictions should be implemented to reduce the likelihood of wounding residual trees.

3) Timber Stand Improvement

This alternative would remove merchantable trees in addition to those identified for sanitation. Trees with undesirable characteristics (i.e., dead tops, poor form, marginal growth) would be harvested to improve stand conditions. Stocking levels would also be adjusted to levels appropriate for the site, stand conditions, and management objectives.

Many of the large, overmature trees would be removed. A younger, thriftier stand would be created. Small openings that remained after logging could be site prepared for seed fall and natural regeneration through harvesting activities. A more open stand would be created. Because of the density and age of the stand, at least two entries would be advisable to reduce the probability of sunscald and windthrow to the residual stand. Stocking levels would be significantly reduced resulting in increased radial growth of individual trees. Because of reduced stocking and sanitation of overmature, decadent trees, future tree mortality should be significantly reduced.

Efforts to reduce the entry of *H. annosum* into the stands, as discussed above in Alternative 2, should be implemented.

ANNOSUS ROOT DISEASE NEAR NEW SHADY REST CAMPGROUND

Observations

Pockets of mortality of Jeffrey pine have been observed by District personnel for many years northeast of the New Shady Rest Campground (T. 3 S., R. 27 E., section 25). This mortality was attributed to infection by annosus root disease (*Heterobasidion annosum*) in conjunction with cortical feeding insects.

An even-aged Jeffrey pine stand is affected. Trees are in the small to medium sawtimber size classes. Tree age is 80-100 years. Annosus root disease centers are numerous and some have coalesced. Centers range up to an acre or more in size. Approximately 50 acres were estimated to be involved based on a quick look at aerial photographs by the District. Current tree mortality is evident around the margins of the centers. Insects observed associated with the mortality were primarily pine engraver beetles (*Ips* spp.). It is probable that the Jeffrey pine beetle (*Dendroctonus jeffreyi*) and red turpentine beetle (*D. valens*), are also involved in the pest complex.

Management Alternatives

1) No Action

Tree mortality can be expected to continue and additional centers will coalesce. Survival of the fungus in individual centers may be up to 50 or more years. During this time, few conifers will be able to survive within centers. With time, the fungus will become inactive in the middle of centers and natural regeneration will survive. A doughnut effect of mortality may be observed around this regeneration. As long as any new pine stumps that are created

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Observations

... of ... Jeffrey pine have been observed ... of the ... Study ... background ... was attributed to ... in conjunction with ...

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continue to be treated with borax, additional root disease centers will not be formed, but the current infected areas will continue to expand through root contacts.

2) Restrict Disease Center Expansion

Attempts would be made to limit further radial expansion of existing root disease centers. Trees within centers would be marked for removal. Outer boundaries of root disease centers would be estimated based on observations of individual trees. A buffer of "healthy" green trees beyond the boundary of each center would also be marked for removal. Based on the rate of spread of the fungus, the period of susceptibility of dead host tissue, and the ability to estimate accurately the boundaries of root disease centers, a 100 foot buffer is recommended. Reducing the buffer to 75 feet may be effective in most cases, but an increased risk of not restricting disease expansion will be incurred. Following tree removal in the disease centers and in the buffers, periodic removal of natural regeneration will be necessary every 10 years for at least 30 years in these openings to make certain that new host material is not provided for survival of the fungus. In about thirty years, infected stump and root material should have decomposed and the fungus lost vitality sufficiently that hosts could be reintroduced. The openings should then be able to support conifers without future root disease-related mortality. Periodic monitoring should be done to insure adequacy of the buffer zone. Bark and engraver beetle-related mortality should decline. Proper slash disposal during harvesting should help reduce the chances of pine engravers attacking leave trees exposed along the edges of the buffer zone.

The time until regeneration may be shortened disrupting the stumps and root systems remaining within the openings after harvesting. Pushing stumps above ground with a dozer blade and brush raking the area to break up and lift the larger roots above ground should accelerate the time for the fungus to die out in the centers. The length of time until successful regeneration could be accomplished (if such actions were implemented) is not known, but 10-15 years appears to be a reasonable estimate.

Because of the number of annosus root disease centers in the area and their proximity to each other, a large area of land would be denuded of conifers for a lengthy period of time. Considerable overlap of buffers around individual centers can be expected. Small stringers of trees between buffers might be considered for removal for ease of future stand management.

3) Special Use Designation

Because of the location and relatively flat terrain of this area, the District might consider using it if a large open area is needed. Since tree mortality can be expected to continue throughout the area if no management action is taken, premature removal to provide a sufficiently large opening would not significantly affect stand yield. Similarly, since regeneration is not expected to survive in the centers for many years, turning them over to some special use may not have much impact on their productivity. By utilizing the openings in the root disease centers and possibly expanding beyond their boundaries (creating buffers), the fungus would be allowed to dieout while some

use was being gained from the site. Depending on the nature of the special use, the area could be converted back to conifers, if desired, after about three decades.

LODGEPOLE PINE MORTALITY - WHITE WING

Observations

The area occupies about 100 acres northeast of the White Wing Work Center between Glass Creek Road and Deadman Creek (T. 2 N., R. 27 E., sections 27 and 28). Topographically, the area is a flat grading into a slope on the north edge. The stand is essentially two-storied, even-aged with the overstory about 170+ years of age and 30+ inches DBH. The understory is approximately 70 to 80 years old and 18-20 inches DBH. Species composition is at least 90% lodgepole pine in the flat, but changes to 60% Jeffrey pine as the stand moves up the slope on the north side. This species distribution seems likely due to changes in soil and/or soil moisture characteristics that occur as the flat grades into the slope. Stocking varied between 210 and 300 sq.ft./ac in aggregations with no mortality, to around 90 sq.ft./ac in aggregations that have incurred past mortality. Examination of a small number of increment cores indicates that radial growth of the overstory trees appears to decline after about 90 years and after about 60 years in the understory trees. The stand was precommercially thinned and underburned in 1978-79. Some of the 70-90 year old Jeffrey pine show an increase in growth over the last 4 to 6 years, perhaps indicating a response to the thinning. Such a response was not observed in the lodgepole pine. Patches of dense, natural, 5 to 6-year-old regeneration were observed scattered throughout the area, probably in response to the underburning. The regeneration is primarily lodgepole pine, but where some Jeffrey pine has also seeded in, mostly on the north side, the latter seem to have attained height growth dominance after 3 to 4 years.

The District has observed lodgepole pine mortality throughout the area over the last few years, although 1986-87 mortality is relatively low. Examination of currently infested trees and standing older dead trees indicates that the mountain pine beetle (MPB), *Dendroctonus ponderosae*, is associated with the mortality. Relatively little mortality was observed in the flat; most appeared in the north side area where the gradual slope begins and where the lodgepole and Jeffrey pine start to intermingle. Most of the mortality was concentrated in lodgepole 30 inches DBH or more, although a few 20 inch DBH trees had been attacked. A few suppressed, unthrifty lodgepole had MPB patch or strip-killed areas along the the lower and mid-bole. No Jeffrey pine beetle activity was observed in the stand.

Management Alternatives

1) No Action

Mountain pine beetle-related lodgepole pine mortality can be expected to continue as long as old, large-diameter, slow-growing, susceptible hosts remain in the stand. Mortality levels will vary from year-to-year, tending to be higher when additional stress factors, such as below normal precipitation,

impact the stand. As the older, larger trees die, openings will be created and eventually become occupied primarily by dense patches of lodgepole regeneration. Some Jeffrey pine regeneration will likely become established on the north side of the area where the slope begins. The MPB is a native insect that has co-evolved with lodgepole pine, and is one factor tending to perpetuate an even-aged, lodgepole pine stand on this site. This alternative would provide some benefits to wildlife through increased habitat for snag and downed-log dependent species. No costs or benefits associated with green or salvage sales would be incurred or realized. No action could result in some level of increased fire hazard depending on actual mortality rates.

2) Salvage

Some commercial value would be realized by salvaging the dead and dying trees. This alternative would not change the underlying factors predisposing the trees to MPB (i.e., age-related reduced growth and vigor; competition) and mortality would continue in the older, large-diameter trees. This would necessitate frequent stand entries accompanied by associated administrative costs. Vegetative succession would continue essentially as in the No Action alternative except to the extent that regeneration and the residual trees are damaged during salvage operations. Fire hazard should not increase, depending on adequate slash disposal (particularly if the logging were conducted during the winter), and may decrease because of the removal of dead trees. Benefits to certain wildlife species, principally those dependent on snags and downed logs in the stand, would be less than under the No Action alternative.

3) Thinning

Selective removal of the large diameter trees should reduce the level of MPB-related mortality until the residual understory and regeneration becomes susceptible at around 20 to 25 inches DBH, depending on the growth and vigor of individual trees. This alternative would realize commercial values at green stumpage rates and would not require frequent entries. A diameter cut of 30 inches DBH and larger would reduce current mortality; a diameter cut of 20 to 25 inches DBH and larger would reduce MPB-related mortality at present and into the future. Through time, MPB-related mortality can be expected to increase as the residual stand grows into the susceptible diameter classes. The openings created under this alternative, although still small (<2 acres), would be larger than those resulting from either the No Action or Salvage alternative. Unless replanted, the openings would gradually regenerate naturally with lodgepole pine. If no other treatments were implemented (see Alternative 4, below), an even-aged stand characterized by a mosaic of densely stocked, suppressed aggregations would develop. Fire hazard and wildlife benefits would be essentially the same as under the Salvage alternative.

4) Timber Stand Improvement/Sanitation

This alternative is intended to apply to trees under 20 inches DBH and should be realistically considered for implementation only in conjunction with Alternative 3-Thinning. Implemented by itself, this alternative might have some long-term benefits as described below, but would have little or no effect on the existing tree and stand conditions creating susceptiblity to MPB. Under this alternative, trees would be removed for the purpose of reducing competition and creating desired levels of stocking. In general, poorly

[illegible] the older, [illegible] than [illegible] [illegible] by [illegible] (especially [illegible]) [illegible] some [illegible] of [illegible] [illegible]. [illegible] pine regeneration will likely [illegible] establish [illegible] side of the area where the slope [illegible]. [illegible] that has [illegible] with lodgepole pine, [illegible] one factor [illegible] perpetuate a even-aged, lodgepole pine stand on this site. This alternative would produce some benefits to wildlife through increased [illegible] downed [illegible] dependent species. No costs or [illegible] [illegible] piles would be [illegible] or [illegible] [illegible] [illegible] [illegible] hazard [illegible] [illegible] natural mortality.

[illegible]

[illegible] would be [illegible] [illegible] [illegible] not change [illegible] [illegible] (i.e. age-related [illegible] [illegible] competition [illegible] [illegible] [illegible]. This [illegible] [illegible] stand [illegible] [illegible] by associated [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible] to the extent [illegible] [illegible] during [illegible] are [illegible]. [illegible] should [illegible] [illegible] (particularly [illegible] the logging [illegible]), and may [illegible] because of the removal of [illegible] trees. [illegible] [illegible] species, principally those dependent [illegible] and [illegible] in the stand, would be less than under the [illegible] Action [illegible].

[illegible]ning

[illegible] removal of the large diameter trees should reduce [illegible] level [illegible] [illegible] (until the residual understory [illegible] [illegible] [illegible] around 20 to 25 inches [illegible], depending on the growth [illegible] individual trees. This alternative would [illegible] [illegible] [illegible] and would not require [illegible] activities. [illegible] DBH and larger would reduce current mortality [illegible] [illegible] inches DBH and larger would reduce [illegible] mortality [illegible] [illegible]. Through time, [illegible] mortality [illegible] [illegible] [illegible] residual stand grows into the susceptible diameter classes. The openings [illegible] alternative, although small ([illegible] acres), would [illegible] resulting from either the No Action or Salvage alternative. [illegible] openings would gradually regenerate naturally [illegible] no other treatments were implemented (see Alternative [illegible]), [illegible] aged stand characterized by a mosaic of [illegible] [illegible] would develop. [illegible] hazard and wildlife [illegible] [illegible] as under the Salvage alternative.

[illegible]/Restoration

[illegible] to apply to trees under 20 inches DBH and should [illegible] implementation only in conjunction with [illegible] implemented by itself, this alternative might [illegible] described below, but would have little or no [illegible] [illegible] conditions [illegible] susceptibility to [illegible] [illegible] be removed for the purpose of [illegible] stocking. In general, [illegible] only

growing, suppressed trees and individuals with defects or disease would be removed, but spatial considerations (to reduce competition) within aggregations should also be considered. Both commercial and non-commercial sized trees would be involved. This should result in improved growing conditions such that, through time, trees would reach larger diameters somewhat earlier and in a more vigorous condition with reduced susceptibility to attack by MPB. This is dependent, however, on whether the lodgepole pine will show a positive response to thinning. This should be carefully evaluated since the few increment cores taken during the evaluation did not indicate much response to the 1978-79 thinning (although simply maintaining current radial growth might be viewed as a positive response). It should be recognized, however, that eventually, large-diameter lodgepole pine will become susceptible to MPB attack.

5) Direct Control

This alternative would involve identifying trees currently infested with MPB and treating them to kill the brood. Techniques available include felling the infested trees and a) peeling the bark from the infested bole area, b) burning the infested boles, c) spraying the infested bole area with an insecticide or d) prompt utilization (processing for wood products; utilization as firewood) of infested material. All involve the identification of the currently infested trees within the treated area and implementing treatment prior to brood emergence the following year. Generally, the period of identification and removal would be from October to mid-May, depending to an extent on weather. Lindane (EPA Reg. No. 239-2518) is a Restricted Use Pesticide currently registered for control of pine bark beetles by spraying infested material. It requires a special permit from the County Agricultural Commissioner.

All of these direct control methods, if implemented properly, would be effective in killing the within-tree MPB brood. However, the resultant effect on MPB population dynamics, including area-wide population levels, and, most importantly, on subsequent tree mortality in the treatment area, is unknown. Direct control alone does not affect the underlying conditions predisposing the trees to MPB attack. It is possible, even likely, that beetles from untreated areas will reinvade the treated area and attack the still susceptible lodgepole pine. At best, any benefits from direct control would likely be short-term, and, to be most effective, would have to be implemented on a yearly basis. All of these methods would also kill MPB natural enemies; the impact of this on MPB population dynamics and subsequent tree mortality is not known.

6) Pheromones (Insect Behavioral Chemicals)

An additional alternative involves use of the MPB aggregation pheromone (*trans*-verbenol, *exo*-brevicomin and myrcene), either in traps or attached directly to tree boles, to attract adult beetles into a specific part of the stand. This would result in some trees in the vicinity of the baits being attacked and killed. These infested trees would then have to be treated using one of the direct control options discussed above. The intent would be to reduce MPB populations in the stand and surrounding area such that mortality, hopefully over the next few years, would be reduced to acceptable levels. It has been demonstrated that MPB can be attracted to an area and killed using this technique. However, efficacy in terms of reducing tree mortality to acceptable levels has not been shown under conditions such as exist in the

White Wing situation (i.e., low to moderate, non-outbreak, MPB populations; uneven-age management primarily for non-timber objectives). Furthermore, the number and location of the trees likely to be killed by the attacted beetles cannot be accurately predicted. Use of the MPB aggregating pheromone in the manner described has been exempted from registration by the EPA, but it is not known whether a similar exemption would be granted by CDF&A.

A different approach would be the use of the anti-aggregation MPB pheromone (verbenone) to prevent MPB attack. This would probably be a more appropriate strategy to implement in this particular case, but it is still experimental. A "west-wide" experiment testing the MPB anti-aggregation pheromone in both ponderosa and lodgepole pine is planned for FY88 and will hopefully yield positive results leading to operational use in the near future. Depending in part on District interest, it may be possible to conduct limited experimental work with verbenone this summer.

BIOLOGIES OF PEST ORGANISMS

CYTOSPORA CANKER OF TRUE FIRS. *Cytospora abietis* is a canker-causing fungus that infects true firs throughout their range in California. It is a weak parasite, and usually attacks trees that have been weakened by disease, drought, fire, insects, or human disturbance. It is most commonly associated with dwarf mistletoe infection, and sometimes attacks as many as a quarter of the mistletoe-bearing branches, killing many each year. The bright red flags of recently-killed branches on dwarf mistletoe-infected red firs are almost always the result of lethal Cytospora infections. *C. abietis* occasionally reaches especially damaging proportions in certain years, and may attack trees of any age, sometimes killing the tops or all of young trees.

STALACTIFORM RUST (*Peridermium stalactiforme*). This rust fungus attacks lodgepole, Jeffrey, and ponderosa pines. It causes limb rust of Jeffrey pine and main stem cankers of ponderosa and lodgepole pines. These pine hosts support production of orange aeciospores in the spring that are windborne to the alternate hosts, members of the figwort family. Two spore stages (urediospores and teliospores) develop consecutively on the foliage of these alternate hosts. Basidiospores are formed on these hosts in the fall and are wind disseminated short distances to infect pine needles. The fungus then grows down into the pine branch and is perennial.

Infected Jeffrey pines develop symptoms in the lower crown. Cankers develop on individual branches, with subsequent death of the branch and spread of the fungus up the bole. Branch mortality in Jeffrey pine starts in the lower crown and spreads upward. The fungus causes an elongated, sunken canker on lodgepole pine that usually bleeds resin profusely.

WESTERN GALL RUST (*Peridermium harknessii*). Western gall rust causes branch galls and trunk cankers on nearly all species of hard pines. The rust fungus produces yellow to orange-colored spores (aeciospores) on the surface of the galls during cool, moist, spring weather. The spores are wind disseminated and can infect other pines directly. Invasion of the pine bark by the rust fungus results in the formation of woody galls. Galls on branches are typically subglobose or spindle-shaped. The galls continue to enlarge and produce new

spores each spring until they have girdled and killed the branch or stem. Girdling of branches results in a reduction of tree growth. Trunk cankers deform and reduce the strength of the bole.

FIR ENGRAVER (Scolytus ventralis). The fir engraver attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.

ANNOSUS ROOT DISEASE. Heterobasidion annosum is a fungus that attacks a wide range of woody plants, causing a decay of the roots and lower bole and death of sapwood and cambium. All pines in California are susceptible; hardwoods are rarely affected.

The fungus becomes established in freshly cut stumps from air-borne spores produced by fruiting bodies (conks). It then grows into the root system and may spread to adjacent healthy trees via root contacts. Infected pines are usually killed rather rapidly when H. annosum girdles the root collar. After a suitable period of time, conks are produced under the bark of dead trees, in decayed stumps, or in the duff at the root collar.

Local spread of H. annosum through roots results in the formation of disease centers that have dead trees in the middle and dying trees on the margin. These centers usually continue to enlarge until they reach barriers such as openings or groups of non-host plants. The fungus may remain alive for as long as 50 years as a saprophyte in infected roots and stumps. Pines may seed in or be planted in centers and survive for a few years, but they eventually will be infected and die.

MOUNTAIN PINE BEETLE (Dendroctonus ponderosae). The mountain pine beetle attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 4 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines. The mountain pine beetle is generally considered to be the most destructive bark beetle in the West, but in California, the western pine beetle (D. brevicomis), is usually more important.

The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is the general rule, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Natural factors affecting mountain pine beetle abundance include

sub-zero winter temperatures, nematodes, woodpeckers and predaceous and parasitic insects.

Trees weakened by any of several factors, including root disease, dwarf-mistletoe, moisture stress, overstocking, and advanced age, are most susceptible to mountain pine beetle. Attacks may extend from the root collar up the bole to a diameter of about 4 inches. Pheromones released during a successful attack may attract enough beetles to result in a group kill. The sapwood of successfully attacked trees soon become heavily bluestained. The bluestain fungi aid in overcoming the defenses of the host tree. Pitch tubes and red boring dust in bark crevices or on the ground indicate successful attacks. Attacks generally occur from June-September; trees attacked during the later part of this period often do not fade until the following spring.

The adults bore long vertical egg galleries and lay eggs in niches along the sides of the gallery. A "J"-hook is common at the lower end of the gallery. The hatching larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.